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1. Your reference	P.71868 GCW		
			21 OCT 1996
2. Patent application number (The Patent Office will fill in this part)	<b>9621859.9</b>		
3. Full name, address and postcode of the or of each applicant (underline all surnames)	<p>XENOVA LIMITED 240 Bath Road, Slough, Berkshire SL1 4EF, United Kingdom</p> <p><i>43217502</i></p>		
Patents ADP number (if you know it)	United Kingdom		
If the applicant is a corporate body, give the country/state of its incorporation			
4. Title of the invention	Cytokine Production Inhibitors		
5. Name of your agent (if you have one)	J A KEMP & CO		
"Address for service" in the United Kingdom to which all correspondence should be sent (including the postcode)	<p>14 SOUTH SQUARE GRAY'S INN LONDON WC1R 5LX</p> <p><i>26001</i></p>		
Patents ADP number (if you know it)			
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7. If this application is divided or otherwise derived from an earlier UK application, give the number and the filing date of the earlier application	Number of earlier application		Date of filing (day / month / year)
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Description 25

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Statement of inventorship and right to grant of a patent (Patents Form 7/77)

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11.

I/We request the grant of a patent on the basis of this application

Signature *J.A.Kemp & G* Date 21 October 1996

12. Name and daytime telephone number of person to contact in the United Kingdom

Mr G.C. Woods  
0171 405 3292

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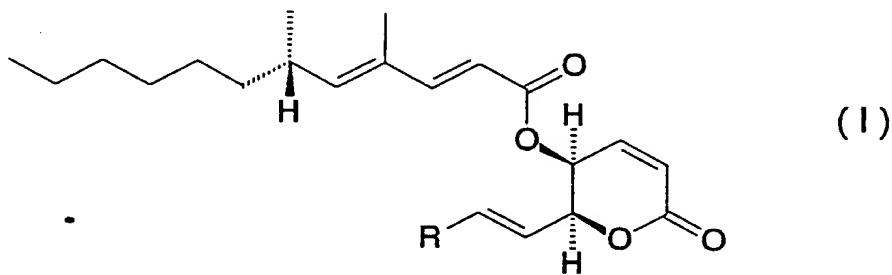
CYTOKINE PRODUCTION INHIBITORS

The present invention relates to 5,6-dihydro- $\alpha$ -pyrones useful as cytokine production inhibitors, to the preparation of 5 these compounds and to pharmaceutical and veterinary compositions containing them.

We have now discovered that fermentation of a strain of the fungus *Phomopsis* sp. in a nutrient medium produces two 5,6-dihydro- $\alpha$ -pyrones esterified in the 5-position with an 10 unsaturated C<sub>14</sub> fatty acid and also the free C<sub>14</sub> fatty acid. We have also discovered that fermentation of a strain of the fungus *Paecilomyces* sp. in a nutrient medium produces a useful phomalactone.

The present invention therefore provides a 5,6-dihydro- $\alpha$ -pyrone of formula (I):

20



wherein R is CO<sub>2</sub>H or CH<sub>3</sub> and, when R is CO<sub>2</sub>H, a pharmaceutically or veterinarily acceptable salt thereof.

25 Preferred compounds of the invention are:

3-((5S,6S)-5,6-dihydro-5-((6S)-4,6-dimethyldodeca-2E,4E-dienoyl)-2H-pyran-2-on-6-yl)-prop-2E-enoic acid; and  
3-((5S,6S)-5,6-dihydro-5-((6S)-4,6-dimethyldodeca-2E,4E-dienoyl)-2H-pyran-2-on-6-yl)-prop-2E-ene.

The present invention provides a process for the preparation of a 5,6-dihydro- $\alpha$ -pyrone of formula (I) or a pharmaceutically or veterinarily acceptable salt thereof, which process comprises:

- 5 (i) fermenting, in a source of carbon, nitrogen and inorganic salts, fungal strain *Phomopsis* sp. 22502 (CBS 313.96) or a mutant thereof which produces a said 5,6-dihydro- $\alpha$ -pyrone;
- 10 (ii) isolating a said 5,6-dihydro- $\alpha$ -pyrone from the fermentation broth; and
- 15 (iii) if desired, when the isolated 5,6-dihydro- $\alpha$ -pyrone is the compound of formula (I) wherein R is CO<sub>2</sub>H, converting the said 5,6-dihydro- $\alpha$ -pyrone into a pharmaceutically or veterinarily acceptable salt thereof.

15 The compounds of formula (I) have been isolated from a microorganism which we have designated X22502 and which has been identified as a strain of the genus *Phomopsis* (Saccardo) Bubák on the basis of the following morphological data with reference to the description given by SUTTON, B.C., 1980 (The 20 Coelomycetes. Farnham Royal: Commonwealth Agricultural Bureaux):

The fungal strain *Phomopsis* sp. (X22502) (CBS 313.96) is a coelomycete isolated from tropical freshwater foam which produces a dense, dark grey-olivaceous (Flora of British Fungi 25 Colour Identification Chart, 1969, Edinburgh: HMSO) mycelium with a white lobate margin at 24°C on 2% malt extract agar with glucose and peptone (MEA: composition per litre of distilled water: Difco malt extract, 20g; Bacto-peptone, 1g; agar, 20g). After 7 days the mycelium attains a diameter of 2.5 - 3.5cm.

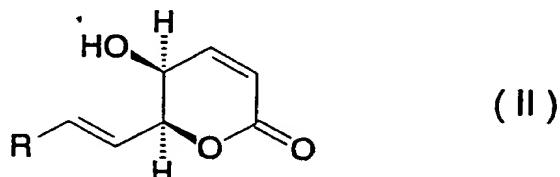
Conidiomatal development is stimulated by exposure to near-UV light. Conidiomata are solitary, carbonaceous, unilocular, ostiolate and measure 1.5 - 2.0mm wide and 1.25 - 2.0mm high. Conidiogenous cells are borne on branched 5 conidiophores which line the conidiogenous cavity. These cells are hyaline, obclavate to cylindrical, integrated, phialidic and measure 16 - 20  $\mu\text{m}$  x 1.5 - 2.0 $\mu\text{m}$ . Conidia are hyaline, aseptate and generally of three types: A-conidia (5.5 - 7.5 $\mu\text{m}$  x 1.5 - 3.0 $\mu\text{m}$ ) are ellipsoid to fusiform, usually with acute 10 apices and a guttule at each end; B-conidia (20 - 32 $\mu\text{m}$  x <1 $\mu\text{m}$ ) are hamate and filiform; C-conidia (9.5 - 11.5 $\mu\text{m}$  x 1.5 - 3.0 $\mu\text{m}$ ) are obclavate with acute apices and usually at least three 15 guttules. All three conidial types can be found within a single conidioma. The fluvial origin and observed microscopical characters did not allow further classification to species.

The 5,6-dihydro- $\alpha$ -pyrones of formula (I) are associated primarily with the mycelium on termination of the fermentation. They may be recovered and purified from the medium. The 20 separation and purification of the compounds from the fermentation broth and their recovery can be achieved using solvent extraction followed by chromatographic fractionation.

The 5,6-dihydro- $\alpha$ -pyrone of formula (I) in which R is CO<sub>2</sub>H may be converted into pharmaceutically or veterinarily 25 acceptable salts by conventional methods. Suitable salts include salts with pharmaceutically acceptable inorganic or organic acids. Examples of inorganic acids include hydrochloric acid, sulphuric acid and orthophosphoric acid. Examples of organic acids include p-toluenesulphonic acid,

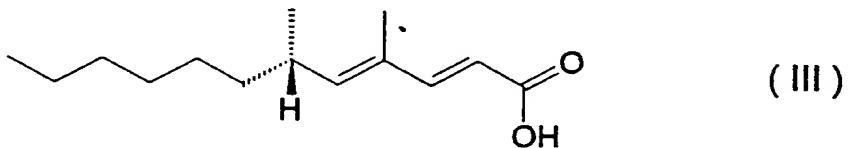
methanesulphonic acid, mucic acid and succinic acid. The salts may themselves be converted into the free compound.

The 5,6-dihydro- $\alpha$ -pyrone of formula (I) wherein R is CH<sub>3</sub>, can, alternatively, be produced by the esterification of the 5 phomolactone of formula (II):



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with (6S)-4,6-dimethyldodeca-2E,4E-dienoic acid which is a fatty acid formula (III):



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Preferably the reaction is carried out in the presence of a dehydrating agent such as DCC (dicyclohexylcarbodiimide) or EDC (20 (1-(3-dimethylaminopropyl)-3-ethylcarbodiimide hydrochloride) and dimethylaminopyridine. The reaction is typically carried out in an inert solvent such as dichloromethane or tetrahydrofuran.

The reagents are generally mixed with stirring for 25 example at a low temperature such as -78°C. The reaction is then allowed to warm to room temperature (20-25°C) and stirred until complete. The reaction may be monitored chromatographically by thin layer chromatography or reversed phase high performance liquid chromatography and is typically

complete within sixteen hours. Other dehydrating agents such as an alkylchloroformate and triethylamine, phenyldichlorophosphate, 2-chloro-1,3,5-trinitrobenzene and pyridine, and chlorosulphonyl isocyanate can also be used under 5 similar conditions.

Alternatively an excess of the phomalactone of formula (II) can be reacted with the acid of formula (III). The water formed can be removed by azeotropic distillation. Suitable solvents include toluene and 1, 4-dioxane. The reaction is 10 typically catalysed by acids such as sulphuric acid and p-toluenesulphonic acid.

It is advantageous to produce the 5,6-dihydro- $\alpha$ -pyrone of formula (I) wherein R is CH<sub>3</sub>, by this route as both the phomalactone and the fatty acid can be produced by fermentation 15 in larger quantities than the 5,6-dihydro- $\alpha$ -pyrone of formula (I) wherein R is CH<sub>3</sub>.

The fatty acid of formula (III) can be produced by a process which comprises:

- (i) fermenting, in a source of carbon, nitrogen and inorganic 20 salts, strain *Phomopsis* sp. 22502 (CBS 313.96) or a mutant thereof which produces the said fatty acid; and
- (ii) isolating the said fatty acid of formula (III) from the fermentation broth.

The fatty acid of formula (III) may, of course, be 25 isolated from the same fermentation broth as the 5,6-dihydro- $\alpha$ -pyrones of formula (I). The fatty acid, like the 5,6-dihydro- $\alpha$ -pyrones, is primarily associated with the mycelium on termination of fermentation.

The phomalactone of formula (II) can be synthesised by

methods known in the prior art, for example those disclosed in Krivobok, S. et al, *Pharmazie*, (1994): 49, H8, 605-607; Guirand, P. et al, *Pharmazie*, (1994): 49, H8, 279-281; Krasnoff, S.B. et al, *J. Chem. Ecol.*, (1994): 20, 293-302 and 5 Murayama, T. et al, *Agric. Biol. Chem.*, (1987): 51, 2055-2060.

The present invention does however provide a new process for the preparation of the phomalactone of formula (II), which process comprises:

- (i) fermenting, in a source of carbon, nitrogen and inorganic 10 salts, fungal strain *Paecilomyces* sp. 3527 (CBS 314.96) or a mutant thereof which produces the said phomalactone; and
- (ii) isolating the said phomalactone from the fermentation broth.

15 The phomalactone is found primarily in the culture liquor on termination of the fermentation and may be recovered and purified. The separation and purification of the compound from the fermentation broth and its recovery can be achieved using solvent extraction followed by application of conventional 20 chromatographic fractionations with various chromatographic techniques and solvent systems.

The phomalactone of formula (II) has been isolated from a microorganism which we have designated X3527 and which has been identified as a strain of the genus *Paecilomyces* Bainier on the 25 basis of the following morphological data with reference to the descriptions given by SAMSON, R.A., 1974 (*Paecilomyces* and some allied *Hyphomycetes*. *Studies in Mycology* No. 6. Baarn: CBS).

The fungal strain *Paecilomyces* sp. (X3527) (CBS 314.96) is an entomogenous hyphomycete isolated from a tropical

Lepidoptera pupa which produces white mycelium attaining 4.5 - 5.0cm diameter within 14 days at 25°C on 2% MEA. The aerial mycelium becomes powdery as conidiogenesis occurs and may develop denser concentric zones. A pale-buff-yellow 5 pigmentation frequently develops in aerial and/or submerged mycelium.

Conidiophores are hyaline and smooth-walled with stipe dimensions of 100 - 400 $\mu$ m x 1.5 - 2.5 $\mu$ m and bear single or sparsely clustered phialides. Phialides are produced with the 10 characteristic morphology of *Paecilomyces* Bainier measuring 7 - 20 $\mu$ m long with a lower section inflated to 2 - 2.5 $\mu$ m wide. The phialide neck is often considerably attenuated (<1 $\mu$ m wide) and bent. Phialides of very variable morphology are also produced, e.g. lacking an inflated basal region and/or with an attenuated 15 neck measuring about 20 $\mu$ m long. Conidia are ellipsoid to cylindrical (3.5 - 7 $\mu$ m x 2 - 3 $\mu$ m), smooth-walled, hyaline and borne in conspicuous imbricate dry chains.

Further classification as a *Paecilomyces* anamorph of *Cordyceps* (Fries) Link may be justified on the grounds of the 20 lepidopterous origin of the isolate coupled with the results of numerous studies made by H.C. Evans and R.A. Samson (unpublished data) of entomopathogenic *Paecilomyces* anamorphs of *Cordyceps*.

The strains X22502 and X3527 were deposited by Xenova 25 Group plc of 240 Bath Road, Slough, Berkshire, SL1 4EF, United Kingdom under the Budapest Treaty at the Centraalbureau voor Schimmelcultures, Baarn, the Netherlands, on 19th March 1996 under references X07/64/502 and X08/64/527 respectively. Strain X22502 was assigned the reference number CBS 313.96. Strain

X3527 was assigned the reference number CBS 314.96.

The present invention also embraces mutants of the above microorganisms. For example, those which are obtained by natural selection or those produced by mutating agents 5 including ionising radiation such as ultraviolet irradiation, or chemical mutagens such as nitrosoguanidine or the like treatments, are also included within the ambit of this invention.

The invention further provides a biologically pure 10 culture of fungal strain X22502 or X3527 or of a mutant thereof which produces the compounds of the invention. Such cultures are substantially free from other microorganisms. The invention also provides a process for fermenting the fungal strain X22502, X3527 or a said mutant, which process comprises 15 fermenting strain X22502 or X3527 or a said mutant thereof in a source of carbon, nitrogen and inorganic salts.

Assimilable sources of carbon, nitrogen and minerals may be provided by either simple or complex nutrients. Sources of carbon will generally include glucose, maltose, starch, 20 glycerol, molasses, dextrin, lactose, sucrose, fructose, carboxylic acids, amino acids, glycerides, alcohols, alkanes and vegetable oils. Sources of carbon will generally comprise from 0.5 to 10% by weight of the fermentation medium.

Sources of nitrogen will generally include soya bean 25 meal, corn steep liquors, distillers' solubles, yeast extracts, cottonseed meal, peptones, ground nut meal, malt extract, molasses, casein, amino acid mixtures, ammonia (gas or solution), ammonium salts or nitrates. Urea and other amides may also be used. Sources of nitrogen will generally comprise

from 0.1 to 10% by weight of the fermentation medium.

Nutrient mineral salts which may be incorporated into the culture medium include the generally used salts capable of yielding sodium, potassium, ammonium, iron, magnesium, zinc, 5 nickel, cobalt, manganese, vanadium, chromium, calcium, copper, molybdenum, boron, phosphate, sulphate, chloride and carbonate ions.

An antifoam may be present to control excessive foaming and added at intervals as required.

10 Fermentation can be conducted at temperatures ranging from 20°C to 40°C, preferably 24-30°C. For optimal results, it is most convenient to conduct these fermentations at a temperature in the range 24-26°C. The starting pH of the nutrient medium suitable for producing the compounds can vary 15 from 5.0 to 8.5 with a preferred range of from 5.0 to 7.5.

Small scale fermentations are conveniently carried out by placing suitable quantities of nutrient medium in a flask by known sterile techniques, inoculating the flask with either spores or vegetative cellular growth of the fungal strain, 20 loosely stoppering the flask with cotton wool, and permitting the fermentation to proceed in a constant room temperature of about 25°C on a rotary shaker at from 95 to 300 rpm for 2 to 10 days. The fermentation may also be conducted in static culture on liquid or semi-solid medium.

25 For larger scale work, it is preferable to conduct the fermentation in suitable tanks provided with an agitator and a means of aerating the fermentation medium. The nutrient medium is made up in the tank after sterilization and is inoculated with a source of vegetative cellular growth of the fungal

strain. The fermentation is allowed to continue for from 1 to 8 days while agitating and/or aerating the nutrient medium at a temperature in the range 20°C to 37°C. The degree of aeration is dependent upon several factors such as the size of the fermenter and agitation speed. Generally the larger scale fermentations are agitated at about 95 to 750 rpm and aerations of about 0.5 to 1.5 VVM (volumes of air per volume of medium per minute).

The separation of the present compounds from the whole 10 fermentation broth and their recovery is carried out by solvent extraction followed by application of chromatographic fractionations with various chromatographic techniques and solvent systems. The present compounds in pure form have thus been isolated in this way.

15 The 5,6-dihydro- $\alpha$ -pyrones of formula (I) and pharmaceutically and veterinarily acceptable salts of the compound of formula (I) wherein R is CO<sub>2</sub>H are inhibitors of the production of cytokines, specifically IL-1 $\beta$ .

These compounds can therefore be used in the treatment of 20 disorders requiring immunosuppression, for example immunoinflammatory conditions and CNS disorders. A human or animal, e.g. a mammal, can therefore be treated by a method comprising administration of a therapeutically effective amount of a compound of formula (I), or a pharmaceutically or 25 veterinarily acceptable salt of the compound of formula (I) wherein R is CO<sub>2</sub>H.

These compounds can be used in the treatment of an immunoinflammatory condition such as rheumatoid arthritis, osteoarthritis, septic shock, psoriasis, atherosclerosis,

inflammatory bowel disease, Crohn's disease and asthma. The compounds of the present invention also exhibit pharmacological properties associated with the treatment of other disorders requiring immunosuppression, for example central nervous system 5 (CNS) disorders such as encephalomyelitis and Alzheimer's disease.

The compounds of the present invention can be administered in a variety of dosage forms, for example orally such as in the form of tablets, capsules, sugar- or film-coated 10 tablets, liquid solutions or suspensions or parenterally, for example intramuscularly, intravenously or subcutaneously. The present compounds may therefore be given by injection or infusion.

The dosage depends on a variety of factors including the 15 age, weight and condition of the patient and the route of administration. Typically, however, the dosage adopted for each route of administration for adult humans is 0.001 to 10 mg/kg, most commonly in the range of 0.01 to 5 mg/kg, body weight. Such a dosage may be given, for example, from 1 to 5 20 times daily orally or by bolus infusion, infusion over several hours and/or repeated administration.

The toxicity of the compounds of the invention is negligible, they can therefore safely be used in therapy.

The compounds of the present invention are formulated for 25 use as a pharmaceutical or veterinary composition also comprising a pharmaceutically or veterinarily acceptable carrier or diluent. The compositions are typically prepared following conventional methods and are administered in a pharmaceutically or veterinarily suitable form.

For example, the solid oral forms may contain, together with the active compound, diluents, such as lactose, dextrose, saccharose, cellulose, corn starch or potato starch; lubricants such as silica, talc, stearic acid, magnesium or calcium stearate and/or polyethylene glycols; binding agents such as starches, arabic gums, gelatin, methylcellulose, carboxymethylcellulose, or polyvinyl pyrrolidone; disintegrating agents such as starch, alginic acid, alginates or sodium starch glycolate; effervesing mixtures; dye-stuffs; sweeteners; wetting agents such as lecithin, polysorbates, laurylsulphates. Such preparations may be manufactured in known manner, for example by means of mixing, granulating, tabletting, sugar coating, or film coating processes.

Liquid dispersions for oral administration may be syrups, emulsions and suspensions. The syrups may contain as carrier, for example, saccharose or saccharose with glycerol and/or mannitol and/or sorbitol. In particular a syrup for diabetic patients can contain as carriers only products, for example sorbitol, which do not metabolise to glucose or which only metabolise a very small amount to glucose. The suspensions and the emulsion may contain as carrier, for example a natural gum, agar, sodium alginate, pectin, methylcellulose, carboxymethylcellulose or polyvinyl alcohol.

Suspensions or solutions for intramuscular injections may contain, together with the active compound, a pharmaceutically acceptable carrier such as sterile water, olive oil, ethyl oleate, glycols such as propylene glycol, and if desired, a suitable amount of lidocaine hydrochloride. Solutions for intravenous injection or infusion may contain a carrier, for

example, sterile water which is generally Water for Injection. Preferably, however, they may take the form of a sterile, aqueous, isotonic saline solution. Alternatively, the compounds of the present invention may be encapsulated within 5 liposomes.

The following examples illustrate the invention

Example 1

**Batch Fermentation of *Phomopsis* sp. 22502**

A 1.5ml cryovial containing 1 ml of macerated vegetative 10 mycelium suspended in a 10% glycerol solution was retrieved from storage at -135°C. A preculture was produced by aseptically placing 1ml of starting material in a 250ml baffled Erlenmeyer flask containing 40ml of nutrient solution S1 and shaken at 240 rpm for 3 days at 25°C.

15 An intermediate culture was generated by aseptically transferring the preculture to 2L of nutrient solution S1 in a 3L fermenter. The fermenter was agitated at 500rpm, aerated at 0.5vvm, and the temperature controlled at 25°C for 3 days.

A production culture was generated by aseptically 20 transferring an intermediate culture to a 75L fermenter containing 50L of nutrient solution P1. The production fermenter was stirred at 350rpm, aerated at 0.5vvm, and temperature controlled at 25°C. After 5½ days incubation the fermentation was stopped and the culture was harvested.

25 The nutrient solutions used were as follows, percentages being by weight:

**Nutrient Solution S1:** 1.5% glycerol, 1.5% soya bean peptone, 1% D-glucose, 0.5% malt extract, 0.3% NaCl, 0.1% CaCO<sub>3</sub>, 0.1%: Tween 80, 0.1% Junlon PW110 [suppliers: Honeywell and Stein,

Sutton, Surrey, U.K.] adjusted to pH 6

**Nutrient Solution P1:** 3.6% molasses, 0.2% casein hydrolysate, 0.004% phytic acid, 0.09% calcium chloride, 0.1%: Tween 80, adjusted to pH 5

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Example 2

**Extraction and purification of the 5,6-dihydro- $\alpha$ -pyrones of formula (I) and the fatty acid of formula (III) from *Phomopsis* sp. 22502**

10 The broth in Example 1 was harvested by filtration using a Schenk Niro 430 filter press, the clarified filtrate was discarded and the retained biomass was extracted with 25L of recirculating methanol for 24 hours. The methanolic extract was harvested via filtration through the filter press and 15 evaporated to an aqueous concentrate using a thin film evaporator.

The aqueous concentrate (10L) was then back extracted with 2 x 7L of an ethyl acetate:hexane (1:1) mix. The solvent extracts were pooled and evaporated to a gum under reduced 20 pressure and redissolved in 50ml of ethyl acetate:hexane (1:1). Purification was achieved by normal phase chromatography using a Biotage Flash 75 chromatography system and a Flash 75 KP-Sil silica (32-62  $\mu$ m 60  $\text{\AA}$ ) column (internal diameter (ID) 7.5 x 30cm length) and an isocratic mobile phase (ethyl 25 acetate:hexane 1:1 mix, 200ml/min flow rate). 1L fractions were collected and analysed by thin layer chromatography using the same mobile phase as the developing solvent.

The 5,6-dihydro- $\alpha$ -pyrone of formula (I) wherein R is  $\text{CO}_2\text{H}$  (Rf 0.53), the 5,6-dihydro- $\alpha$ -pyrone of formula (I) wherein R is

CH<sub>3</sub> (Rf 0.89) and the fatty acid of formula (III) (Rf 0.75) rich fractions were pooled, evaporated to dryness under reduced pressure and subjected to further purification by preparative reversed phase HPLC using a Waters NovaPak C18 (100 Å 5µM) 5 column (ID 2.5 x 20 cm length) and an isocratic mobile phase (80% acetonitrile: 20% water plus 0.1% v/v glacial acetic acid, flow rate 50 ml/min). Wavelength monitoring was at 278nm. The peaks collected at 11-14 minutes, 19-21 minutes and 30-32 minutes were evaporated to dryness to yield the compound of 10 formula (I) (7.5g), the compound of formula (II) (0.35g), and the fatty acid of formula (III) (0.9g) respectively.

Physiochemical data for the three compounds are set out in Tables 1 to 3 below. Tables 2 and 3 show <sup>1</sup>H and <sup>13</sup>C NMR assignments respectively.

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Table 1

	5,6-dihydro- $\alpha$ -pyrone of formula (I)		fatty Acid of formula (III)
	R is CO <sub>2</sub> H	R is CH <sub>3</sub>	
DCI-MS (m/z)	391 (MH) <sup>+</sup>	361 (MH) <sup>+</sup>	225 (MH) <sup>+</sup>
Molecular formula	C <sub>22</sub> H <sub>30</sub> O <sub>6</sub>	C <sub>22</sub> H <sub>32</sub> O <sub>4</sub>	C <sub>14</sub> H <sub>24</sub> O <sub>2</sub>
UV $\lambda_{max}$ nm	206, 276	204, 274	265
IR (KBr) $\nu$ cm <sup>-1</sup>	3391, 2960, 2928, 2855, 1717, 1620, 1570, 1396, 1285, 1250, 1161, 1024, 980.	3390, 2960, 2928, 1720, 1615, 1560, 1250, 1180, 1010, 980.	2900, 2685, 2589 1687, 1618, 1459 1417, 1285, 1207 1028, 984, 940, 852, 700

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Table 2

Position	† $\delta$ H/ppm in MeOH-d4		
	5,6-dihydro- $\alpha$ -pyrone of formula (I)		Fatty Acid of formula (III)*
	R is CO <sub>2</sub> H	R is CH <sub>3</sub>	
5	2		
	3	6.35 (1H, d, 9.7)	6.29 (1H, d, 9.8)
	4	7.21 (1H, dd, 9.7, 5.6)	7.18 (1H, dd, 9.8, 5.6)
10	5	5.64 (1H, dd, 5.6, 3.0)	5.48 (1H, dd, 5.6, 3.1)
	6	5.49 (1H, m)	5.19 (1H, ddq, 7.2, 3.0, 0.9)
15	7	6.91 (1H, dd, 15.7, 5.0)	5.72 (1H, ddq, 15.4, 7.2, 1.7)
	8	6.32 (1H, dd, 15.7, 1.8)	6.05 (1H, dqd, 15.4, 6.6, 1.1)
	9		1.84 (3H, ddd, 6.8, 1.7, 0.8)
20	1'		
	1'-OH		11.70 (1H, br s)
25	2'	5.88 (1H, d, 15.6)	5.95 (1H, dd, 15.7, 0.6)
	3'	7.41 (1H, dd, 15.6, 0.6)	7.41 (1H, dd, 15.6, 0.8)
	4'		
30	5'	5.83 (1H, br d, 9.8)	5.83 (1H, br d, 9.2)
	6'	2.66 (1H, m)	2.65 (1H, m)
35	7'-11'	1.3-1.5 (10H, m)	1.4 (10H, m)
	12'	0.97 (3H, t, 6.9)	0.95 (3H, t, 6.9)
	13'	1.87 (3H, d, 1.1)	1.81 (3H, d, 1.2)
40	14'	1.08 (3H, d, 6.6)	1.09 (3H, d, 6.6)
			0.98 (3H, d, 6.6)

45 \* values obtained in CDCl<sub>3</sub>,

† The J values are in parenthesis (Hz)

50

55

60

Table 3

Position	$\delta$ C/ppm in MeOH-d4		
	5,6-dihydro- $\alpha$ -pyrone of formula (I)		Fatty Acid of formula (III)
	R is CO <sub>2</sub> H	R is CH <sub>3</sub>	
5	2 164.6	165.5	
	3 125.6	126.1	
	4 143.4	143.4	
	5 64.9	65.6	
	6 79.6	81.4	
10	7 139.6	125.5	
	8 128.2	138.8	
	9 170.7	18.2	
	1' 168.0	168.0	173.1
	2' 115.3	115.5	114.7
15	3' 153.5	153.2	152.1
	4' 133.3	133.1	131.2
	5' 151.7	151.5	149.8
	6' 35.0	34.8	33.2
	7' 38.7	38.6	37.1
20	8' 33.4	33.2	31.8
	9' 30.9	30.7	29.3
	10' 29.0	28.9	27.3
	11' 24.1	23.9	22.5
	12' 14.8	14.6	13.9
	13' 12.9	12.7	12.1
25	14' 21.1	20.9	20.2

\* values obtained in CDCl<sub>3</sub>,

30 Example 3

**Batch Fermentation of Paecilomyces sp. 3527**

Starting material of the strain *Paecilomyces* sp. 3527 was generated by suspending a mature slant culture, grown on MEA (2% malt extract, 1.5% agar), in 5ml 10% aqueous glycerol. 1ml of this suspension, in a 1.5ml cryovial, comprises the starting material which was retrieved from storage at -135°C. A preculture was produced by aseptically placing 1ml of starting material in a 250ml baffled Erlenmeyer flask containing 40ml of nutrient solution S2 shaken at 240 rpm for 3 days at 25°C.

40 An intermediate culture was generated by aseptically transferring the preculture to 2L of nutrient solution S2 in a 3L fermenter. The fermenter was agitated at 500rpm, aerated at

0.5vvm, and the temperature controlled at 25°C for 3 days.

A production culture was generated by aseptically transferring an intermediate culture to a 75L fermenter containing 50L of nutrient solution P2. The production fermenter was stirred at 300rpm, aerated at 0.5vvm, and temperature controlled at 25°C. During the production fermentation the pH was uncontrolled and remained between 5.5 and 6.5. In addition the dissolved oxygen tension remained above 80%. After 5 days incubation the fermentation was stopped and the culture was harvested.

The solutions used were as follows, percentages being by weight:

**Nutrient Solution S2:** 1.5% glycerol, 1.5% soya bean peptone, 1% D-glucose, 0.5% malt extract, 0.3% NaCl, 0.1% CaCO<sub>3</sub>, 0.1% Tween 80, 0.1% Junlon PW110 (Honeywell and Stein, Sutton, Surrey, U.K.) adjusted to pH 6

**Nutrient Solution P2:** 3.65% sucrose, 1.20% glutamic acid (sodium salt), 0.02% K<sub>2</sub>HP0<sub>4</sub>, 0.98% MES, 0.05% KCl, 0.1% Tween 80, 0.002% MgSO<sub>4</sub>, 0.002% CaCl<sub>2</sub>, 2% vitamin mix solution (see below), 0.5% trace elements solution (see below), adjusted to pH 6

**vitamin mix solution:** 0.0025% thiamine, 0.0025% riboflavin, 0.0025% pantothenate, 0.0025% nicotinic acid, 0.0025% pyridoxine, 0.0025% thioctic acid, 0.00025% folic acid, 0.00025% biotin, 0.00025% cyanocobalamin, 0.00025% p-amino benzoic acid, 0.005% vitamin K, 0.2% Tween 80.

**trace elements solution:** 0.17% ZnSO<sub>4</sub>, 0.11% FeSO<sub>4</sub>, 0.02% MnSO<sub>4</sub>, 0.006% H<sub>3</sub>BO<sub>3</sub>, 0.012% CuSO<sub>4</sub>, 0.005% Na<sub>2</sub>MoO<sub>4</sub>, 0.005% CoCl<sub>2</sub>, 0.008% KI.

Example 4

**Extraction and purification of the phomalactone from  
*Paecilomyces* sp. 3527**

The fermentation broth from Example 3 was harvested by  
5 filtration and the clarified filtrate was divided equally into  
3 aliquots and each aliquot was back extracted batch wise with  
10L of hexane to remove non-polar impurities. The hexane  
extracts were separated and discarded. Each batch of filtrate  
was then back extracted with 2 x 8L of ethyl acetate. The  
10 phomalactone and some impurities were extracted into the  
solvent while many of the more polar impurities remained in the  
aqueous phase. The ethyl acetate extracts were pooled and  
concentrated to dryness under reduced pressure and redissolved  
in 50ml of ethyl acetate.

15 Purification was achieved by normal phase chromatography  
using a Biotage Flash 75 chromatography system and a Flash 75  
KP-Sil silica (32-62  $\mu$ m 60 $\text{\AA}$ ) column (internal diameter 7.5 x  
30cm length) and an isocratic mobile phase (100% ethyl acetate,  
200ml/min flow rate). 1L fractions were collected and analysed  
20 by thin layer chromatography using ethyl acetate as the  
developing solvent.

Phomalactone rich fractions ( $R_f$  0.75) were pooled,  
evaporated to dryness under reduced pressure and subjected to  
further purification by preparative reversed phase HPLC using a  
25 Beckman 350 HPLC with a Shandon Hyper prep HS BOS C18 (100  $\text{\AA}$   
12 $\mu$ m) column (internal diameter 10 x 30 cm length) and an  
isocratic mobile phase (85% water:15% acetonitrile, flow rate  
170ml/min). Wavelength monitoring was at 210nm. The peak  
collected between 6-12 minutes was evaporated to dryness to

yield the target phomalactone (6.0g).

Physiochemical data for the phomalactone are set out in Tables 4 to 6 below. Tables 5 and 6 show  $^1\text{H}$  and  $^{13}\text{C}$  NMR assignments respectively.

5 Table 4

		Phomalactone of formula (II)
	DCI-MS ( <i>m/z</i> )	155 (MH) <sup>+</sup>
	Molecular formula	$\text{C}_8\text{H}_{10}\text{O}_3$
	UV $\lambda_{\text{max}}$ nm	200
10	IR (KBr) $\nu$ $\text{cm}^{-1}$	3425, 2923, 2855, 1716, 1629, 1381, 1262, 1157, 1102, 1076, 1034, 969, 830.

Table 5

Position	$\dagger\delta\text{H}/\text{ppm}$ in $\text{CDCl}_3$ ,	
	Phomalactone of formula (II)	
15	2	6.12 (1H, d, 9.6)
	3	6.97 (1H, dd, 9.7, 5.2)
	4	4.21 (1H, dd, 5.2, 3.2)
	5	4.85 (1H, m)
20	6	6.00 (1H, ddd, 15.3, 6.5, 1.0)
	7	5.75 (1H, ddq, 17.0, 6.9, 3.4)
	8	1.82 (3H, ddd, 6.1, 1.0)
	9	

25 <sup>†</sup> The *J* values are in parenthesis (Hz)

Table 6

30

Position	$\delta\text{C}/\text{ppm}$ in $\text{CDCl}_3$ ,	
	Phomalactone of formula (II)	
35	2	162.9
	3	122.8
	4	144.3
	5	63.1
	6	80.9
40	7	132.9
	8	123.8
	9	17.8

Example 5

Synthesis of the 5,6-dihydro- $\alpha$ -pyrone of formula (I) wherein R is CH<sub>3</sub>, by esterification of the phomalactone with the fatty acid of formula (III).

5 A solution of the phomalactone (20mg, 0.13mmol 1eq) in dry dichloromethane (2ml) was added to a stirred solution of the fatty acid of formula (III) (29mg, 0.13mmol), 1-(3-dimethylaminopropyl)-3-ethylcarbodiimide hydrochloride (24.8mg, 0.13mmol, 1eq) and dimethylaminopyridine (1mg) in dry dichloromethane (5ml) at -78°C. The reaction mixture was allowed to warm to room temperature and was stirred for a further 16 hours. The reaction mixture was washed with saturated ammonium chloride solution (3 X 5ml), water (1 X 5ml) and brine (1 X 5ml). The organic extract was dried over MgSO<sub>4</sub>, 15 filtered and concentrated *in vacuo* yielding a yellow oil. Purification by preparative reversed phase HPLC yielded the 5,6-dihydro- $\alpha$ -pyrone of formula (I) wherein R is CH<sub>3</sub> (11.1mg). HPLC, TLC, and <sup>1</sup>H NMR analysis showed that this product was identical to the isolated natural product.

20

Example 6

**TNF- $\alpha$  Release from U937 Cells**

The effect of the compounds of the invention on TNF- $\alpha$  release was investigated using a known method (Lozanski, G. et 25 al., (1992), J. Rheumatol; 19, 921-26).

The human histolytic lymphoma U937 cell line was obtained from a commercial source (ECACC, Salisbury, UK) and maintained in RPMI 1640 medium supplemented with 2mM L-glutamine and 5% fetal bovine serum. The cells were pretreated with 25 ng/ml

PMA for six hours and then exposed to dose ranges of the compound to be tested followed by the addition of 1 ng/ml LPS.

After 18 hours incubation at 37°C with 5% CO<sub>2</sub> the cell culture supernatants were harvested and stored at -70°C, until required for determination of TNF- $\alpha$  secretion by Dissociation Enhanced Lanthanide Fluorescence Immuno Assay (DELFIA). The effect of the compounds on cell cytotoxicity was measured using the tetrazolium salt, XTT (2,3-bis[2-methoxy-4-nitro-5-sulphophenyl]-2H-tetrazolium-5-carboxanilide salt) and effects on protein synthesis were determined by investigation of [<sup>3</sup>H] Leucine uptake.

In this test the compounds of the invention were found to inhibit TNF- $\alpha$  release at concentrations of from 10 to 0.1  $\mu$ M (Table 7). At this concentration range, the compounds were not toxic and showed no effect on protein synthesis. The IC<sub>50</sub> ( $\mu$ M) values for LPS-induced TNF production in U937 cells for the 5,6-dihydro- $\alpha$ -pyrones for formula (I) are given in Table 8.

20 Example 7

**IL-1 Release from Human Monocytes**

The effect of the compounds of the invention on IL-1 $\beta$  release was investigated using a known method (Bakouche, O. et al., (1992), J. Immunol: 148, 84-91). Human monocytes were purified by elutriation from Buffy coats obtained from normal healthy donors after the separation of peripheral blood mononuclear cells (PBMC) on Lymphoprep. The freshly isolated monocytes were suspended in RPMI 1640 supplemented with 5% FBS and exposed to dose ranges of the compound to be tested

followed by the addition of 1 ng/ml LPS. Cells were incubated for 18 hours at 37°C with 5% CO<sub>2</sub> and the cell culture supernatants harvested and stored at -70°C. Effects on the production of IL-1 $\beta$  were determined using an ELISA.

5 The compounds of the invention were found to inhibit the release of IL-1 $\beta$  at concentrations of from 0.2 to 10  $\mu$ M (Table 9). At this concentration range the compounds were not toxic to monocytes. The IC<sub>50</sub> ( $\mu$ M) values for LPS-induced IL-1 $\beta$  production for the 5,6-dihydro- $\alpha$ -pyrones of formula (I) are  
10 given in Table 8.

15

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Table 7: Inhibition of TNF- $\alpha$  release

	Concentration $\mu\text{M}$	% Inhibition of TNF- $\alpha$
R in formula (I) is $\text{CO}_2\text{H}$	8	107
	2	100
	0.5	77
	0.12	47
5 R in formula (I) is $\text{CH}_3$	2.8	99
	0.7	90
	0.17	61
	0.04	20
	0.01	0.85

Table 8:  $\text{IC}_{50}$ s for inhibition of LPS-induced cytokine

10 production by the 5,6-dihydro- $\alpha$ -pyrones of formula (I)

	$\text{IC}_{50}$ ( $\mu\text{M}$ )	
R in Formula (I)	LPS-induced TNF production in U937 cells	LPS-induced IL- $\beta$ production (monocytes)
$\text{CO}_2\text{H}$	2	2
$\text{CH}_3$	0.08	0.19

Table 9: Inhibition of the release of IL-1 $\beta$

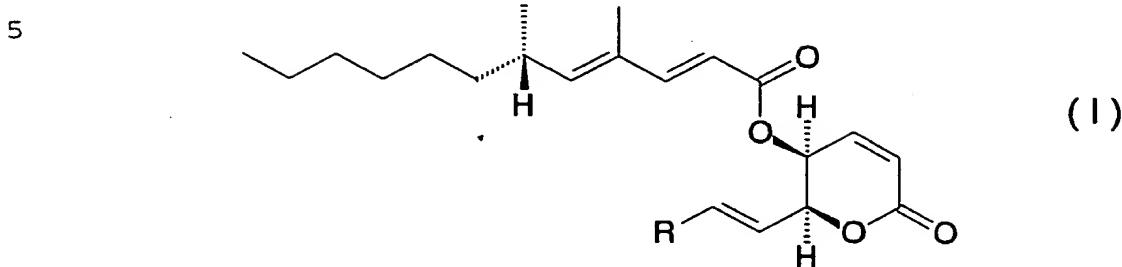
20

	Concentration $\mu\text{M}$	% Inhibition of IL-1 $\beta$
R in formula (I) is $\text{CO}_2\text{H}$	20	99
	2	81.5
	0.5	14
25 R in formula (I) is $\text{CH}_3$	5.5	88
	1.1	72
	0.22	41
	0.044	23

30

CLAIMS

1. A 5,6-dihydro- $\alpha$ -pyrone of formula (I)



10

wherein R is CO<sub>2</sub>H or CH<sub>3</sub> and, when R is CO<sub>2</sub>H, a pharmaceutically or veterinarily acceptable salt thereof.

2. A process for the preparation of a 5,6-dihydro- $\alpha$ -pyrone of formula (I) as defined in claim 1 or a pharmaceutically or veterinarilly acceptable salt thereof, which process comprises:

(i) fermenting, in a source of carbon, nitrogen and inorganic salts, fungal strain *Phomopsis* sp. 22502 (CBS 313.96) or a mutant thereof which produces a said 5,6-dihydro- $\alpha$ -pyrone;

(ii) isolating a said 5,6-dihydro- $\alpha$ -pyrone from the  
fermentation broth; and

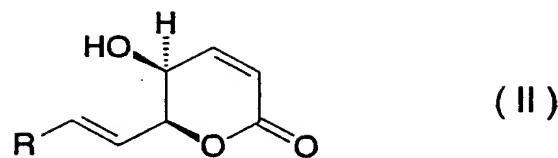
(iii) if desired when the isolated said 5,6-dihydro- $\alpha$ -pyrone is the compound of formula (I) wherein R is CO<sub>2</sub>H,

25 converting the said 5,6-dihydro- $\alpha$ -pyrone into a  
pharmaceutically or veterinarilly acceptable salt thereof.

3. A process for the preparation of a 5,6-dihydro- $\alpha$ -pyrone of formula (I), as defined in claim 1, wherein R is  $\text{CH}_3$ , which process comprises esterifying the phomalactone of formula

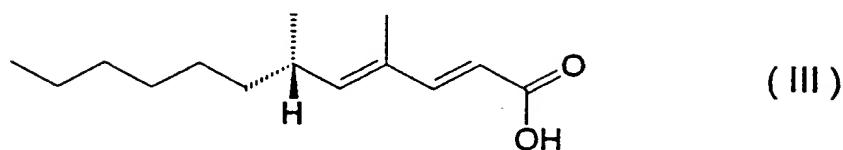
(II) :

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(II)

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(III)

4. A pharmaceutical or veterinary composition comprising a pharmaceutically or veterinarily acceptable carrier or diluent and, as active ingredient, a compound as claimed in claim 1.

5. A compound according to claim 1 for use in a method of treatment of the human or animal body by therapy.

6. A compound according to claim 5 for use as a cytokine production inhibitor.

7. A compound according to claim 6 for use as a IL-1 production inhibitor.

8. A compound according to claim 6 for use in the treatment of an immunoinflammatory condition.

25 9. A compound according to claim 8 for use in the treatment of rheumatoid arthritis, osteoarthritis, septic shock, psoriasis, atherosclerosis, inflammatory bowel disease, Crohn's disease or asthma.

10. A compound according to claim 6 for use in the

treatment of a central nervous system disorder.

11. A process for the preparation of the phomalactone defined in claim 3, which process comprises:

(i) fermenting, in a source of carbon, nitrogen and inorganic salts, fungal strain *Paecilomyces* sp. 3527 (CBS 314.96) or a mutant thereof which produces the said phomalactone; and

(ii) isolating the said phomalactone from the fermentation broth.

10 12. A process for the preparation of the fatty acid defined in claim 3 which process comprises:

(i) fermenting, in a source of carbon, nitrogen and inorganic salts, fungal strain *Phomopsis* sp. 22502 (CBS 313.96) or a mutant thereof which produces the said fatty acid; and

15 (ii) isolating the said fatty acid from the fermentation broth.

13. A biologically pure culture of fungal strain *Phomopsis* sp. 22502 (CBS 313.96) or a mutant thereof which produces a 5,6-dihydro- $\alpha$ -pyrone of formula (I) as defined in

20 claim 1 or a fatty acid of formula (III) as defined in claim 3.

14. A biologically pure culture of fungal strain *Paecilomyces* sp. 3527 (CBS 314.96) or a mutant thereof which produces the phomalactone defined in claim 3.

15. A process for fermenting fungal strain *Phomopsis* sp. 22502 (CBS 313.96) or a mutant thereof as defined in claim 13, which process comprises fermenting strain *Phomopsis* sp. 22502 (CBS 313.96) or a said mutant thereof in a source of carbon, nitrogen and inorganic salts.

16. A process for fermenting fungal strain *Paecilomyces*

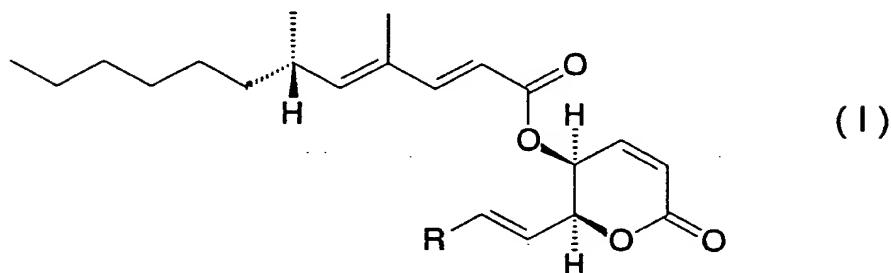
sp. 3527 (CBS 314.96) or a mutant thereof as defined in claim 14, which process comprises fermenting strain *Paecilomyces* sp. 3527 (CBS 314.96) or a said mutant thereof in a source of carbon, nitrogen and inorganic salts.

ABSTRACT

CYTOKINE PRODUCTION INHIBITORS

A 5,6-dihydro- $\alpha$ -pyrone of formula (I)

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wherein R is CO<sub>2</sub>H or CH<sub>3</sub>, and, when R is CO<sub>2</sub>H, a pharmaceutically or veterinarianily acceptable salt thereof. Processes for producing compounds of formula (I) and their use as cytokine 15 production inhibitors.



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